Aktas Energy LLP

Mirny (Kazakhstan) 1GW Wind Farm Project

ESBS Appendix F - Ichthyofauna Survey Report

2021

24685792 -002-R-Rev.04

Materials and methods

The material was collected in autumn 2021 in the lower reaches of the Shu River. Three large floodplain systems were selected for the study of the ichthyofauna of floodplain water bodies: Ulanbel, Kamkalinskaya and Akzhaikinskaya. In the Ulanbel and Kamkal floodplain systems, the two most full-flowing lakes at the time of the study, Karakol and Bolshiye Kamkale, were surveyed. At the end of the lowest system, two lakes, Akzhaikyn and Akkol, located about 40 km apart, were surveyed.

To catch fish in the floodplain lakes, fixed gillnets with a mesh size of 24-90 mm were used. One net was set in each lake. The nets were set at night for at least 12 hours.

The study of the species composition of the ichthyofauna, the collection and processing of ichthyological material was carried out according to generally accepted methods [1].

The relative abundance was converted into the ratio of the number of specimens per net day (catch per 100 m of nets per 24 hours) [2].

A total of 255 fish specimens were caught and analysed.

Physical and geographical description of the study area

The Shu River basin in the catchment area is located almost entirely within Kyrgyzstan, on the slopes of the Kyrgyz Range. Only its lower part, located in the foothills and semi-desert zone, enters Kazakhstan. The Chu basin, with an area of about 148,000 $^{km^2}$,borders the Syr Darya (Naryn) basin to the south, the Talas basin to the west, the Ili basin to the north, and the Issyk-Kul basin to the east. The river is about 1,100 km long. For a long stretch of its course through Kyrgyzstan, the Shu River also serves as the administrative border between Kyrgyzstan and Kazakhstan. Within Kazakhstan, the Shu River has no tributaries except for the Kuragaty River, which flows into it on the left, at the border of the Moyinkum Sands. The Shu River, 1,000-1,100 km from its source, deep in the Moyinkum Sands, ends in a chain of isolated lakes of the Akzhaikyn System, the largest of which, Lake Saumal-Kul, is the final reservoir for the river's flow. In the lower reaches, the river water becomes significantly salinated [3].

The Shu River's catchment area is located partly in the high mountain zone, above the line of eternal snow, and partly in the lower mountain and foothill zone, in an area where only "seasonal" snow accumulates. Accordingly, rivers of this mixed type are fed both by the melting of glaciers and snowfields and by the melting of winter snow reserves in the lower parts of the basin. Due to these characteristics of the catchment basin, rivers of this type experience a series of successive floods and high water levels, starting with the spring snowmelt period and ending with the melting of glaciers and high-altitude snow reserves. Mixed-type rivers have the most favourable distribution of annual runoff for practical use. However, due to the diversion of water for irrigation from both the river and its tributaries during certain summer months, the river carries less water than in autumn and winter, when irrigation ceases. In the winter months, due to the cessation of water diversion for irrigation and a decrease in evaporation, the average monthly flow increases. The Shu River and its tributaries are a major source of irrigation both within Kyrgyzstan and in Kazakhstan [3].

On the border with Moyinkum, the last tributary, the Kuragaty River, flows into the Shu River from the Kyrgyz Range, bringing its waters to the Shu River only during high water. Near the village of Moyinkum, the Shu River turns northwest, sharply slowing its flow. Its channel divides here into several branches, which during high water form the vast Ulanbel and Kamkaline floodplains. The area of the Shu River basin within Kazakhstan is 67,500 $^{km^2}$(including closed areas in the lower reaches and adjacent desert areas). The catchment area enclosed by the weir near the village of Amangeldy below the confluence with the Kuragaty tributary is 38,400 km^2. Currently, the river's flow in the Kazakh part of the territory is monitored at three hydrological stations: Blagoveshchenskoye, Tashkhtul, Ulanbel (in the channels Bolshaya Arna, Malaya Arna). The Amangeldy hydrostation was closed in 1993 and moved to the Moyikum hydroelectric complex, which was closed in July 1998 [4]. The lowest, terminal lakes of the Shu River basin are the Akzhaikyn system — a drainless salt lake (or group of lakes) at the bottom of the Ashchikol depression in the north-west of the Suzak district of the Turkestan region. The average area of the floodplain system is 48.2 km², with a depth of 3 m. The volume of water varies depending on the amount of precipitation. The coastline is flat. During the flood period, the waters of the Shu River reach the lake, while during the rest of the year, the river disappears into the sands of Muyinkum [5].

Our research into the fish fauna as part of the project was conducted on the floodplain lakes of the lower reaches of the Shu River, which consist of three floodplain lake or floodplain systems: Ulanbel, Kamkalinskaya and Akzhaikinskaya. In each system, the lakes with the highest water levels at the time of the research were selected for study.

Lake Karakol. It is part of the Ulanbel system of floodplain lakes. According to available sources, Lake Karakol is classified as a fishery reservoir and is located in the middle reaches of the Shu River, 25-30 km east of the village of Ulanbel. The area of the lake is highly variable and depends on the volume of water flow in the Shu River. For example, in 2001, Lake Karakol had an area of about 460 hectares [6]. By mid-summer, the lake is usually divided into two basins. The maximum depth of the lake reaches 3.5 m (average 2.0 m). The bottom of the lake is almost flat, the clayey-sandy soil is covered with black silt and the remains of undecomposed vegetation, which, when stirred up, gives off a strong smell of hydrogen sulphide. When the water level in the lakes is low, fish kills are possible in summer and winter. The overgrowth of water bodies with above-water vegetation (reeds, rushes, cattails) reaches 25-30%; underwater vegetation accounts for 50-65%.

The dynamics of the lake's water regime are influenced by a number of factors, both natural (inflow and precipitation, evaporation and filtration) and anthropogenic (regulation of river flow, use for irrigation, drainage regime). These factors are closely interrelated, and it is not possible to separate them in the overall water balance of the lakes.

Ice formation begins in the second half of December, and the ice breaks up in late March to early April. Depending on weather conditions, the ice thickness can reach 25-80 cm. In early April, the water temperature reaches 9-12$^{(0)}$ ^{C}, and in May – up to 20(0$^{)}$ ^{C}. In shallow areas in spawning grounds, the water temperature in April-June is 1-2 degrees higher. In general, the water content of the river directly affects the habitat conditions of aquatic organisms, mainly through changes in temperature, flooding of lakes, and the influx of biogens.

The dissolved oxygen content in the water ranges from 2 to 14 mg/l. The pH is slightly alkaline at 7.2-7.6, the average water hardness is 15.9 mg.eq/l, and the permanganate oxidisability is 7.0-14.3 mg/l. Total mineralisation is about 945-1240 mg/l. In general, it can be noted that the hydrochemical regime is suitable for the fishery use of the reservoir [6].

Studies conducted between 1990 and 2001 showed that the food base of the lakes in the middle and lower reaches of the Shu River has undergone changes. In the lakes of the middle and lower reaches, there was a tendency towards a decrease in the biomass of the food base, from very high-nutrient to high-nutrient lakes, with zooplankton stocks declining by 3-6 times [7]. In Lake Karakol in 2001, there was a deficit of zooplankton [6].

In the macrozoobenthos of all lakes of the Shu River, from the Tashkuli Reservoir to Lake B. Kamkalu, there is a huge deficit of benthic organisms. In Lake Karakol, the abundance and biomass of zoobenthos characterised the reservoir as a very low-nutrient reservoir.

The highest aquatic and submerged vegetation in the lakes of the middle and lower reaches of the Shu River occupies up to 30-70% of their area.

In general, it can be noted that, in terms of higher aquatic vegetation and zooplankton, the water bodies of the middle and lower reaches of the Chu River can be characterised as highly nutritious, while the , in terms of macrozoobenthos, where there is a severe shortage of food organisms, can be characterised as low or very low in nutrients [6].

Lake Bolshie Kamkaly is part of the Kamkalsky system of floodplain water bodies or floodplains and has a water surface area of about 700 hectares. The lake is supplied with water by bottom springs, atmospheric precipitation, but mainly by spring flood waters of the Shu River. Due to the complete regulation of the river and the construction of the Tashkakul

Reservoir (which has the status of an irrigation reservoir) in the middle reaches, the bulk of the flood waters are retained in it. Water is released from the Tashkakul Reservoir only after it has been filled to its design level. Since the lake is located in the lower reaches of the river, there is not enough floodwater to fill its water area. Thus, during the periods 1982-1983, 1985-1988, and 1993-95, no fish were caught because the lake was dry during these periods [6].

The bottom of the lake is flat, with sandy and sandy-silty soil. The average depth is within 3.5 metres, with a maximum depth of about 6 metres. The lake is brackish and pear-shaped. With stable water levels, the chemical composition of the water is quite favourable for aquatic life. With the lake's current water balance – filling up until April and draining until November-December – not only are outbreaks of various species possible, but also their extinction, as well as frequent changes in the dominant species in the fishery. In general, the hydrochemical regime is favourable for aquatic organisms to inhabit the lake with a guaranteed water supply. With low water levels in winter and a significant hydrogen sulphide content in the silt, fish kills and deaths are possible. Sufficient water availability in 1998-2001 made it possible not only to increase the commercial fish stocks of the lake, but also to catch up to 50 tonnes of fish there [6].

The Akzhaikyn floodplain lake system. The largest and most permanent lake in this floodplain system is Lake Akzhaikyn. The lake is located in the Suzak district of the Turkestan region in the lower reaches of the Shu River. In 2004, the maximum area of Lake Akzhaikyn was 5,620 hectares. (In rare years of high water, the area increases due to the overflow of water into the salt marshes.) The bottom of the lake is flat, with sandy-silty soil. The average depth is within 1.8 metres, and the maximum depth is about 5.4 metres. The lake is brackish up to 7 parts per thousand [8]; according to our data, in October 2021, the salinity was 9.5 parts per thousand. The lake is supplied with water by atmospheric precipitation, but mainly by spring flood waters from the Shu River. Flood waters are not always sufficient to fill the Akzhaikyn Lake. Thus, during the periods 1982-1983, 1985-1988, and 1993-99, no fish were caught in the lake, as Lake Akzhaikyn practically dried up during these periods and thousands of tonnes of fish died from freezing. Since 2000, water has been flowing into the lower reaches of the Shu River and filling the reservoir, resulting in the restoration of the fish fauna. In terms of its importance for fisheries, it has the status of a periodically frozen reservoir with an unreliable water supply. Since 2003, there has been spontaneous fishing for valuable commercial fish species such as carp, asp, snakehead and pike. In general, the hydrochemical regime is favourable for the habitation of hydrobionts with a guaranteed water supply. With low water levels in winter and summer and a significant content of hydrogen sulphide in the silt, fish kills and fish mortality are possible [8].

Lake Akkol. In addition to Lake Akzhaikyn, we have also included Lake Akkol, located 40 km upstream of the left branch of the Shu River – Shetki Shu, in the same system. Lake Akkol is an inter-barchan depression filled by both flood waters from the river and a self-draining well. We do not have information on the water flow in this well, but visual observations suggest that there is enough water to maintain a favourable hydrological regime in the lake throughout all seasons. The bottom of the lake is silty and sandy, with depths reaching at least 3 m. The shores throughout the entire water area are overgrown with reeds 5-20 m wide, with small man-made clearings.

Lake Akkol is classified in fisheries regulations as a floodplain reservoir of the Shetka Shu channel in the Suzak district of the Turkestan region. We have not found any information on the hydrology and other data on this lake in the sources available to us. However, Lake Akkol is mentioned in the report of VITA LLP in a general description of the problems of fisheries use of the lower reaches of the Shu River: "The species composition of the ichthyofauna of the Shu River basin within the South Kazakhstan Region is represented by nine species: carp, bream, roach, pike perch, rudd, ide, snakehead, Aral asp, pike and perch. The main commercial species are carp, snakehead, pike, and asp. Commercial stocks were intensively exploited from 2003 to 2004 in the Akzhaikyn lake system. Due to their remoteness from regional centres and processing and sales facilities, some fishing areas are not exploited commercially. Another major limiting factor is the lack of access roads to many areas. The exploitation of commercial stocks along the Shu River, its tributaries, the Shetka River, and Lake Akkol is problematic. [8]

Information about the fish fauna of the lower reaches of the Shu River, the history of its formation, study and economic use.

The basins of small water bodies located between the Aral Sea and Lake Balkhash are classified as part of the Aral sub-basin [3]. Thus, the Shu River basin is similar to the Aral basin in terms of its fish fauna composition. In Kazakhstan, the Shu River has two distinct hydrological conditions that form different biotopes and, accordingly, different species compositions of ichthyofauna. The geography of the basin determines its conditional division within Kazakhstan into steppe and desert lower zones. Below are data on the historical distribution of the indigenous ichthyofauna during the period of the basin's natural hydrological regime.

The steppe zone of the Shu River is characterised by high water turbidity and significant erosion of soft forest banks as a result of rapid flow (0.5-1.5 m/sec). The bottom is sandy, silted in places, and on the riffles it is coarse sandy or consists of compressed sandstone and small pebbles. Due to the great depths, the hydrothermal regime is more even than in the foothill zone. The food base is richly developed in the tributary reservoirs and very poor in the channel part, which leads to predation of such peaceful fish as the marinka, Aral and Turkestan barbel. The ichthyocenoses of the steppe zone of the river are represented by fish of the Turkestan complex: *Capoetobrama kuschakewitschi*, *Alburnoides bipunctatus,* thermophilic forms of the Aral fauna - Turkestan barbel (*Luciobarbus capito conocephalus)*, catfish (*Silurus glanis)*, carp *(Cyprinus carpio),* roach (*Rutilus rutilus),* rudd (*Scardinius erythrophthalmus)*, representatives of the mountainous Asian fauna that have descended from the upper zones (*Schizothorax argentatus,* Tibetan char (*Triplophysa stoliczkai)* and newcomers from the north*:* dace (*Leuciscus leuciscus),* ide (*Leuciscus idus),* pike (*Esox lucius),* perch *(Perca fluviatilis)*.

The desert zone of the Shu River (from the village of Moyinkum to the lower reaches). The current is slow, which contributes to the heavy overgrowth of the lower zone's water bodies; the channel is often lost in the reeds, breaking into separate branches (uzaki). The water is clear, and the soils are silty sands, grey and black silts. The water in the cut-off lakes and oxbows has increased mineralisation due to excessive evaporation. These water bodies are subject to summer and winter freezing. The ichthyocenoses are represented by fish of the Aral complex - carp, asp (*Aspius aspius)*, roach, rudd, catfish, and less commonly Aral and Turkestan barbel, as well as representatives of the Siberian ichthyofauna - perch, pike, and ide [9].

Probably due to its lesser importance for fisheries compared to the Aral and Balkhash basins, information about the ichthyofauna of the Shu River is not as extensive. Studies of the fish population of these rivers were begun in the 19th century by N.A. Severtsev. Detailed information on the species composition was obtained by P.A. Dryagin as a result of the work of a comprehensive Kyrgyz expedition of the USSR Academy of Sciences, the results of which were published in 1936. Subsequent studies were conducted by F.A. Turdakov and I.A. Pivnev [10]. In the following years, the ichthyofauna of this river was studied by N.Sh. Mamilov, G.N. Dukravets [11], F.V. Klimov [12], and others. In the middle of the 20th century, research began on the parasitofauna of fish from the water bodies of southern Kazakhstan, in particular from the Shu River with its delta lakes and branches [13].

Fisheries use of ichthyofauna

The commercial use of fish stocks in the lower reaches of the Shu River has been unstable for at least 70 years, largely due to fluctuating hydrological conditions. Due to the prolonged degradation of the Shu River basin ecosystem, most water bodies have lost their commercial value. By the end of the 20th century, the Kamkalinskaya lake system in the lower reaches of the Shu River had lost its commercial fishing significance due to complete regulation of the flow. In the 1950s, these floodplains, together with the Kazotskaya floodplain system on the Talas River, yielded up to 500 tonnes of fish annually [14]. However, as of 1965-1967, even the lowest lake, Akzhaikyn, retained some significance for fisheries [12].

After a prolonged imbalance in the water resources of the Shu River basin, a favourable hydrological regime was established for a short period. At the beginning of the 21st century, fisheries research was conducted during a period of heavy flooding. This period was favourable for the development of fish stocks in the lower reaches of the Shu River. For example, during the period 1974-2000, the Akzhaikyn lake system was the terminal lake of the Shu River, and the riverbed could no longer be traced downstream. However, the years 2001-2004 were full-flowing, which ensured the annual filling of the entire Shu floodplain system. The Shu River not only filled its entire floodplain, but also expanded its usual boundaries. Further through the Akzhaikyn lake system, the Shu River entered the Ashikkol lake system and merged with the Sarysu River and Lake Telekul. The inflow of water into Lake Telekul contributed to the flooding of the reservoir, and during the spring spawning period, a significant part of the fish fauna, mainly pike, asp, carp and snakehead, rose to Lake Akzhaikyn and formed a resident population there. Thanks to good spawning conditions in the spring, there was a sharp increase in the number of carp, and by 2004, commercial stocks had increased to 1,500 tonnes [8]. In this regard, in 2005, fisheries science recommended optimal allowable catches (OAC) in the Akzhaikyn lake system for all five species totalling 350 tonnes (Table 1).

Table 1. Fish limits recommended by scientific research in the floodplain reservoirs of the Shu River, in tonnes

Fish species	Akzhaikyn lake system	Lake Karakol	Lake Bolshiye Kamkally	
	As of 2005	As of 2002	As of 2000	For 2002
Pike	5.2	2	15	2
Bream	-	2	5	5
Ide	-	1	5	1
Roach	6.6	-	2	2
Asp	5.8	-	5	1
Crucian carp	-	6	-	-
Carp	324.4	3	22	14
Perch	-	-	1	2
Snakehead	8	1	2	2
Total	350	14	57	29

During this period, fish stocks remained relatively stable in other fishery floodplain reservoirs in the lower reaches of the Shu River, Lake Karakol and Lake Bolshiye Kamkaly. However, available data on quotas show a downward trend in the total quota for Lake Bolshie Kamkaly over a period of just two years, falling by almost half from 57 to 29 tonnes. The limits for such valuable commercial species as pike have been sharply reduced by 7.5 times, carp by 1.5 times, asp and ide by 5 times. Only the limit for perch has been increased by 2 times. By 2021, the total catch limit for all commercial species in Lake Bolshiye Kamkaly was only 2.6 tonnes, which is 22 times less than the limit for 2000 (Table 2). However, it should be noted that the limits recommended by fisheries science (Table 1) and the limits approved by the competent authorities (Table 2) may differ significantly.

We can indirectly obtain up-to-date information on the state of the fishing industry and the commercial use of fish fauna in the lower reaches of the Shu River from the annually approved fishing quotas (Table 2) [15, 16, 17]. Information on the basin and the values of the approved limits vary from year to year and create certain difficulties in analysis. Over a number of years, it is possible to track the dynamics of the decline in fish stocks based on available data only for Lake Akzhaikyn and Lake Karakol. According to the 2005 MSY and the approved limits for 2008 and 2021, a sharp decline in fish stocks is clearly visible. Thus, in the Akzhaikyn system, fish stocks decreased from 350 to 8.6 tonnes, and in Lake Karakol from 14 to 3.6 tonnes.

Table 2. Government-approved limits on fish catches in the Shu River basin, in tonnes

Fish species	2008			2021	
	Akzhaikyn lake system	Shu River in Zhambyl Region (excluding Lake Karakol)	Lake Karakol	Lake Bolshiye Kamkaly	Lake Karakol
Pike	0.89	4.69	1.17	0.58	1.14
Perch	0.33	7.93	1.98	-	-
Pike perch	-	-	-	-	-
Carp	-	9.19	2.29	1.43	0.9
Crucian carp	0.07	-	-	-	0.75
Roach	2.49	12.31	3.07	-	-
Bream	0.37	1.45	0.36	0.63	0.84
Asp	0.22	2.85	0.71	-	-
Ide	3.17	8.97	2.24		-
White amur	-	0.21	-	-	-
Snakehead	0.52	8.97	2.24	-	-
Total:	8.06	56.57	14.06	2.64	3.63

The information provided on the correlation between water content in reservoirs and the positive dynamics of fish stock recovery clearly demonstrates the ability of biota to recover quickly in a short period of time when optimal conditions for development are present. It goes without saying that the lower reaches of the Shu River basin have a huge need for water resources, not only for development, natural existence and economic use, but also for the survival of the region's ecosystem as a whole.

Problems of preserving the diversity of the fish fauna of the lower reaches of the Shu River

While at the dawn of the study of the Shu River's fish fauna, the main goal was to assess its fish stocks and decide how to exploit them, in recent years the main focus has been on the conservation of biological diversity. Studies conducted in the late 20th and early 21st centuries have shown that the diversity and distribution of alien fish species in the basins of both rivers continue to change [18, 19]. However, the ichthyofauna of the Shu River basin has suffered relatively less from the invasion of introduced species, largely due to the large number of native species (25) that have resisted the pressure of alien species (16 species), 12 of which are new to the republic. However, both species of barbel and the endemic sharp-snouted catfish, listed in the Red Book of Kazakhstan [20], as well as the Siberian dace and marinka, have practically disappeared from the fish fauna here. The numbers of catfish and common perch, which still remain in the lower reaches of the basin, have declined sharply [21].

The above information mainly highlights the problems of fish fauna diversity in the middle reaches of the Shu River. We have not found any information on the current state of fish fauna in the lower reaches of the Shu River in terms of biological diversity.

The disappearance of the Shu sharptail (*Capoetobrama kuschakewitschi orientalis*) is a pressing issue for the preservation of fish fauna diversity. This endemic subspecies is the only species of its genus, inhabiting only the Aral Sea basin. G. V. Nikolsky (1934) distinguishes two subspecies: 1) the typical subspecies, *Capoetobrama kuschakewitschi kuschakewitschi (Kessler),* is found in the Syr Darya from the Karadarya to the lower reaches, and 2) the Shuya ostrolučka, *S. kuschakewitschi orientalis Nikolsky,* is found in the Shuya River from Tokmak to Gulyayevka (now the village of Moyinkum). The Shui sharpnose differs from the typical form in its smaller body height, large head, large eye diameter and smaller dorsal spine. This species is distributed in the rivers of the Aral Sea basin It avoids blind branches with stagnant water and spawns from mid-April to late June. According to G. V. Nikolsky, it is a rheophilic form [22].

It is evident that this subspecies, and possibly the endemic species of ostryoluchka in the Kazakh part of the Aral basin, has been irretrievably lost. A previously small subspecies. After 1960, there is no reliable information about its numbers. Special searches in the basin from Tokmak to the village of Ulanbel in the lower reaches in different seasons from 1990 to 1993 during route expeditions yielded negative results [18]. According to information from the Red Book of Kazakhstan, the limiting factors are unknown. Apparently, there has been a sharp increase in the irretrievable withdrawal of water for irrigation from the Shu River [20].

Results of field studies

Control net catches showed the presence of commercial fish fauna in the surveyed water bodies. The current composition of the fish population in the floodplain water bodies of the lower reaches of the Shu River is presented in Table 3. A total of eight commercial fish species were recorded in scientific net catches in all water bodies. Roach and rudd are mandatory elements of the fish community in all surveyed water bodies. The results of the studies show that the floodplain water bodies of the lower reaches of the Shu River, which have a common problem of water scarcity and relatively similar landscape and ecological conditions in the surrounding area, have different species compositions of their fish communities. The distribution of species across all surveyed water bodies is not uniform. Their relative abundance in terms of catch per unit effort, expressed in terms of specimens per net day, also varies. The largest number of fish species and their relative abundance were recorded in Lake Akkol and Lake Bolshiye Kamkally. The floodplain systems are separated from each other by considerable distances - the length of the study area is about 300 km. The hydroecological conditions for the existence of ichthyofauna vary and, as a result, the species composition and ratio of species in terms of relative abundance are also different. In addition to hydrological conditions, the availability of water bodies to the local population has a significant impact on the fish fauna. For example, Lake Karakol, which is the uppermost lake in the study area and is believed to have a more stable water balance, had the poorest species composition in scientific net catches. Only four species of fish were recorded in catches from this lake. This is comparatively less than the number of species recorded in the highly salinated and practically degraded Lake Akzhaikyn. The anthropogenic factor is evident in this example. Lake Karakol is relatively close and accessible to the population of neighbouring settlements. Lake Karakol is included in the list of fishery water bodies. In addition, the lake is located on the territory of a hunting farm and is popular with hunters and amateur fishermen. In the terminal lake Akzhaikyn and the uppermost of the surveyed reservoirs, Lake Karakol, an imbalance in the fish communities has been noted. In Lake Akzhaikyn, 85% of the catch is roach, while in Lake Karakol, 58% is rudd. Lake Karakol is also characterised by the poorest species diversity and the lowest relative abundance of fish species in catches.

Table 3. Species composition and relative abundance of fish fauna in the lakes of the lower reaches of the Shu River (in specimens per net)

Fish species	Lake Akzhaikyn	%	Lake Akkol	%	Lake B. Kamkaly	%	Lake Karakol	%
Zherekh	8	1.8	24	5.9	20	4.2	-	-
Redfin	8	1.8	32	7.8	96	20.3	48	54.5
Bream	-	-	104	25.4	80	16.9	-	-
Perch	-	-	100	24.4	64	13.6	-	-
Roach	376	85.5	76	18.6	152	32.2	16	18.2
Carp	40	9.1	-	-	-	-	-	-
Pike perch	8	1.8	4	1.0	-	-	-	-
Pike	-	-	13	3.2	40	8.5	16	18.2
Ide	-	-	56	13.7	20	4.2	8	9.1

Of the surveyed water bodies, Lake Bolshie Kamkaly is also classified as a fishery. Here, despite the presence of the small village of Shyganak in the immediate vicinity, seven commercial fish species have been recorded in scientific net catches.

Lake Akkol is characterised by the greatest diversity and balance in the relative abundance of recorded fish species. Eight species of fish have been recorded here, which is the maximum number of species for the entire period of our research.

It should be noted that we recorded four more fish species on the shore of Lake Akkol. The remains of a snakehead, which was absent from our catches, were found, including five heads of fairly large individuals, presumably up to 60 cm in length. It is obvious that these heads were discarded by local fishermen. One snakehead specimen, 19 cm long, was noted by us during biological analysis in the stomach of a caught pike. Also, in the catches of local fishermen, fairly large specimens of pike perch, up to 60 cm, carp up to 50 cm and crucian carp up to 20 cm were noted. We observed a fourth species of non-commercial fish fauna in vivo in shallow water – presumably young Chinese gobies. Thus, the species composition of the fish fauna of Lake Akkol, as recorded by our research, consists of 12 species of fish. This is the maximum diversity observed during the research period in all water bodies. The relatively rich species diversity of Lake Akkol is probably due to the favourable hydrological regime (replenishment by a self-flowing well) and its remoteness from populated areas. At the same time, despite its remoteness, discarded Chinese-made nylon nets have been found on the shore of . Fishermen with similar nets have also been observed.

The biological parameters of the caught specimens of different fish species in all surveyed water bodies were normal. The females of all noted species had gonads at stage 3 of maturity. No individuals with developmental abnormalities or internal organ anomalies were found in the catches. At the same time, it should be noted that there was a high degree of infection (66%) of rudd from Lake Karakol with ligulosis. Ligulosis was also noted in one individual bream in Lake Bolshiye Kamkally.

Conclusion

The survey of the lower reaches of the Shu River as part of the project revealed the presence of ichthyofauna in the Ulanbel, Kamkal and Akzhaikyn floodplain water systems. Commercial fish species were found in all control water bodies. The biological parameters of individuals from scientific net catches indicate satisfactory living conditions for the existing populations. At the same time, an imbalance in the ichthyocenoses was noted in the terminal lake Akzhaikyn and the uppermost of the surveyed reservoirs, Lake Karakol. The state of the fish community in Lake Akzhaikyn is clear: the reservoir has severely degraded due to a catastrophic shortage of water resources in the lower reaches of the Shu River.

Lake Karakol is characterised by the poorest species diversity and the lowest relative abundance of fish species in catches, which is obviously due to both reduced water content and significant fishing pressure.

The species composition of the commercial fish fauna is mainly represented by native species. Among the commercial alien species present in the fish communities is the snakehead. A non-commercial alien representative of the goby family (genus and species not determined) has also been noted.

Based on the analysis of available sources and our own research, we can say with a high degree of certainty that an endemic fish subspecies, the Chui ostrolučka, has disappeared from the lower reaches of the Shu River basin.

Studies conducted on the water bodies of the lower reaches of the Shu River have shown a high level of degradation of both the riverbed and the floodplain system. A retrospective analysis of the literature has shown that the problem of water scarcity in the region is not new, as evidenced by a number of authors. Most researchers attribute the water shortage in the lower reaches of the Shu to the obvious irreversible water consumption for irrigation in the upper part of the basin. As a result of the transboundary nature of the Shu River, most of the water resources are consumed in Kyrgyzstan. According to an intergovernmental agreement, the neighbouring state consumes 58% of the flow, despite having a significantly smaller length of the basin on its territory. At the same time, in Kazakhstan, the Tashutkol Reservoir and the region's outdated irrigation system contribute significantly to the disruption of the hydrological regime of the lower reaches of the Shu River.

In conclusion, it should be added that the restoration of the fish fauna of the lower reaches of the Shu River is necessary for general environmental reasons. The floodplain system of the lower reaches of the Shu River is an important area for fish-eating and other water birds. During the migration period, a large number of rare and endangered bird species concentrate here, such as Dalmatian and pink pelicans, Bewick's swans, ospreys, white-tailed eagles and others.

From a social perspective, the restoration of fish stocks in the lower reaches of the Shu River is necessary to implement WHO recommendations, according to which each person should consume at least 16 kg of fish per year. Given the remoteness of the surveyed region's settlements from large cities, the local population needs to be able to obtain high-quality fish products from local water bodies.

Recommendations

As is well known, the development of fish fauna, the restoration of its diversity and its economic use cannot be discussed without adequate water levels in water bodies. The main decision of organisations working in the field of water resource management and water users should be progressive rational water consumption.

The main recommendation for the conservation and development of the fish fauna of the lower reaches of the Shu River should be to restore the water content of this part of the basin to a state close to natural.

In parallel with the development of measures to restore water levels, it is necessary to organise sustainable monitoring of the state of not only the fish fauna, but also the entire biota of the region.

After restoring water levels, it will be necessary to develop specific fish farming and fishing recommendations for each floodplain water system. For example, the organisation of the rescue of young fish in cut-off reservoirs, the organisation of fish rescue during winter kills, and the stocking of valuable and/or rare fish species to restore ichthyocenoses.

Some measures to ensure the survival of fish fauna during natural disasters should be organised now. This requires the creation of mobile groups of observers to monitor the condition of water bodies and rescue workers from among local residents and/or natural resource users (fishers).

The development of recommendations for restoring the water content of the lower reaches of the Shu basin lies within the professional domain of hydrologists.

Back in 2014, some Kazakh hydrologists came to this conclusion: "An analysis of domestic and foreign experience in regulating anthropogenic pressure on river basins has shown that there are no environmental standards regulating anthropogenic pressure on river basin ecosystems, and there is no methodology for environmental regulation. Existing proposals for standards and criteria for anthropogenic pressure only characterise the specific impact of individual types of economic activity; comprehensive criteria are imperfect. The resolution of a number of problematic issues is hampered by the lack of an environmental monitoring system based on detailed and long-term stationary studies of anthropogenic changes in elements of the natural environment. [23]

Thus, it should be added to the above that one of the most important recommendations should be the development of monitoring of the region in all parts of the ecosystem – hydrology, biota, and the social sphere.

In today's world, one of the important areas of human life is the opportunity to obtain recreational services and organise leisure activities. The development of ecological tourism in the lower reaches of the Shu River for the population of megacities will improve the living standards of local residents by developing employment in the service sector – hotels, public catering, transport maintenance, etc.

List of references

1. Pravdin I.F. Guide to the study of fish. Moscow: Food Industry, 1966. 306 p.
2. On the approval of the Rules for the preparation of biological justification for the use of wildlife. Order of the Minister of Environment and Water Resources of the Republic of Kazakhstan No. 104-Ө of 4 April 2014.
3. Essays on the Physical Geography of Kazakhstan. Published by the Academy of Sciences of the Kazakh SSR, Alma-Ata, 1952. p. 512.
4. Vagapova A. R. Hydrological regime and flooding of the floodplain of the lower reaches of the Shu River // Water Management of Kazakhstan. - 2010. - No. 3. - P. 19-24
5. Kazakhstan. National Encyclopaedia. — Almaty: Kazakh Encyclopaedia, 2004. — Vol. I.
6. Report on scientific research work "Assessment of the state of fish stocks and biological basis for fish catch forecasts for 2002", Almaty 2001.
7. Kitaev S. P. On the ratio of certain trophic levels and "trophic scales" of lakes in different natural zones. Abstracts of reports from the 5th Congress of the All-Union Society of Biologists. Tolyatti. Kuibyshev, 1986. pp. 254-255.
8. Biological justification. Recommendations on fish stocking, rational use of fish stocks and improvement of fishing rules in the water bodies of South Kazakhstan Region, Shymkent, 2004.
9. Pivnev I. A. Fish of Kyrgyzstan. Frunze, 1990. 190 pp.
10. Mitrofanov V. P. History of the study of the ichthyofauna of Kazakhstan // Fish of Kazakhstan. Alma-Ata. Science of the Kazakh SSR, 1986
11. N. Sh. Mamilov, G. M. Dukravets, G. K. Balabieva, F. Kh. Khabibullin. Changes in the fish population of the Chu River and its tributaries. // Biodiversity and the role of animals in ecosystems: Proceedings of the VI International Scientific Conference. – Dnipropetrovsk: DNU Publishing House, 2011. – pp. 100-102.
12. Klimov F.V. The state of the ichthyofauna of the Akzhaikyn lake system in the lower reaches of the Shu River // Fisheries research in the Republic of Kazakhstan: History and current state. Almaty: Bastau, 2005. pp. 186–193.

13. Agapova A.I. Parasites of fish in the water bodies of Kazakhstan. Alma-Ata, 1966. 342 pp.
14. Tair M.T. Fish farming and fishing. - Alma-Ata: Kainar, 1985 - p. 344
15. On the approval of limits for the catch of fish and other aquatic animals in fishery waters for 2008. Resolution of the Government of the Republic of Kazakhstan No. 73 of 28 January 2008
16. On the approval of limits for the removal of wildlife from 1 July 2019 to 1 July 2020. Order of the Minister of Agriculture of the Republic of Kazakhstan No. 240 of 17 June 2019.
17. On the approval of limits for the removal of wildlife from 1 July 2020 to 1 July 2021. Order of the Minister of Ecology, Geology and Natural Resources of the Republic of Kazakhstan No. 133 of 5 June 2020.
18. Dukravets G.N., Mamilov N.Sh. The state of populations of rare and endangered fish species in the Ili and Chu river basins // KazSU - Almaty, 1994 - 25 p. Dep. in KazgosINTI 06.06.94, No. 5049-Ka94
19. Mamilov N.Sh. Current diversity of alien species in the Chu and Talas river basins // Russian Journal of Biological Invasions No. 1 2011 pp. 65-76
20. Red Book of the Kazakh SSR. Vol. 1. Animals. 2nd ed., revised and supplemented. Alma-Ata: Gylim, 1991. 560 pp.
21. Dukravets G.M. On alien fish species in the Republic of Kazakhstan. Dep. TsNB, Almaty 2013.
22. Nikolsky G.V. Materials for understanding the geographical variability of Capoetobrama kuschakewitschi (Kessler) // Dokl. AN SSSR, 1934. Vol. 2. No. 3. P. 200-204/
23. Duskaev K.K., Zhanabaeva Zh.A. Nature conservation and environmental permits as the basis for the preservation of aquatic ecosystems in the lower reaches of rivers. // Bulletin of the Kazakh-German University: Sustainable Development of Central Asia. No. 2 (4), Almaty 2014. pp. 168-171